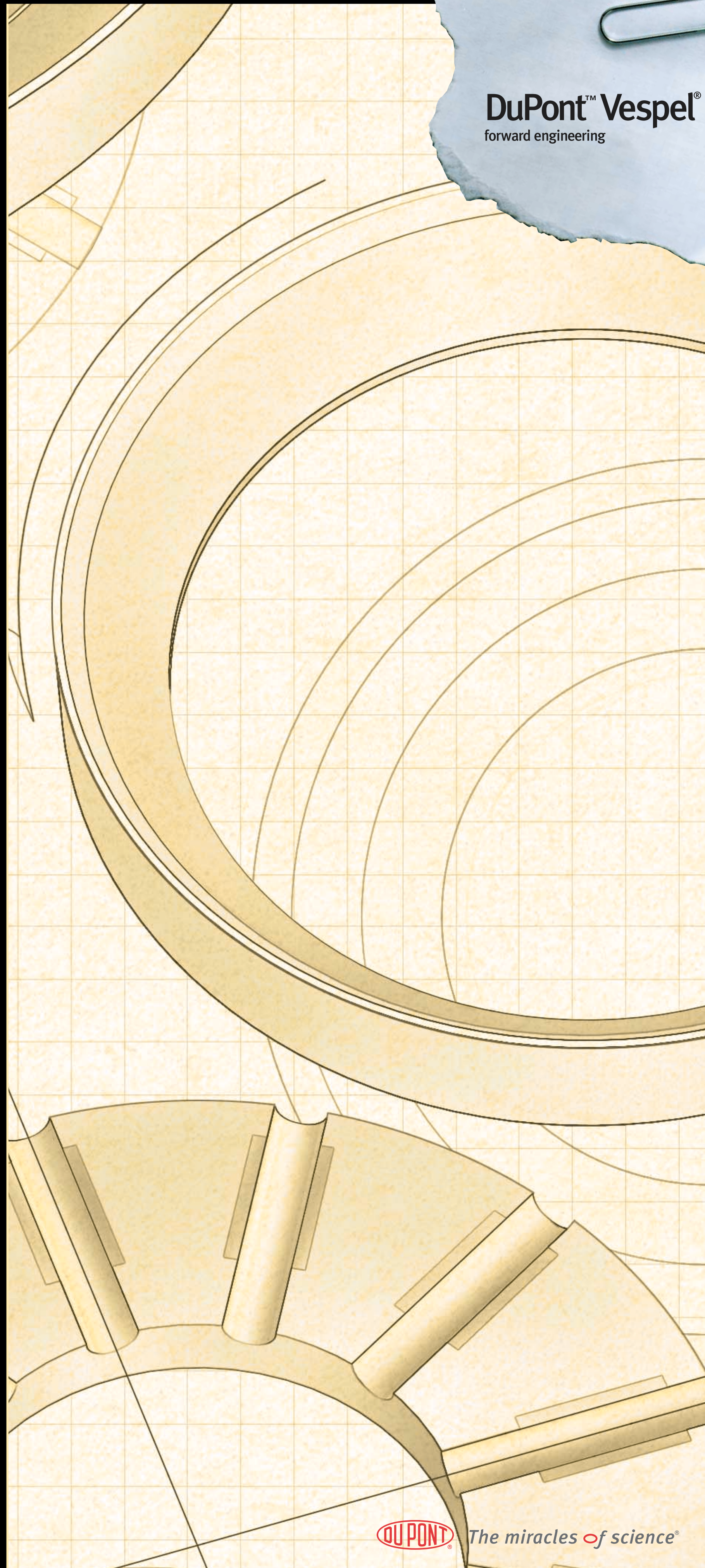
VESPEL®

CR-6100

FOR SUPERIOR CENTRIFUGAL PUMP PERFORMANCE

APPLICATION AND INSTALLATION GUIDE



DuPont™ Vespel®
forward engineering

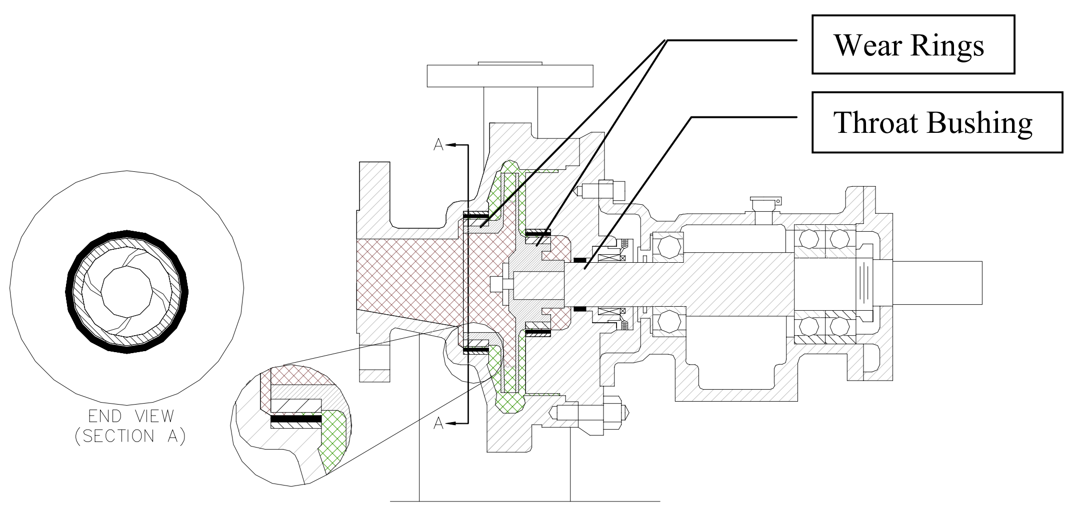
DUPONT® The miracles of science®

Vespel® CR-6100: Application and Installation Guide for Centrifugal Pump Stationary Wear Parts

Background

The CR-6100 grade of DuPont ™ Vespel® parts and shapes is a composite material consisting of carbon fibers held in a Teflon ® fluorocarbon resin matrix. Vespel® CR-6100 has been installed in hundreds of pumps in refineries, chemical plants, power plants, and other fluid processing facilities since 1996. It has replaced metal and other composite materials used for pump wear rings, throat bushings, and line shaft bearings resulting in superior performance. The properties of Vespel® CR-6100 help to reduce the risk of pump seizure and allow internal rotating-to-stationary part clearances to be reduced by 50% or more.

Fluid processing industries have embraced the use of composite materials in pumps to reduce vibration, increase mechanical seal life and MTBR (mean time between repair), reduce the risk of seizure, increase efficiency, and reduce repair costs. API 610, 9th Edition, the latest centrifugal pump standard from the American Petroleum Institute (API), recognizes the use of composites to achieve these benefits.



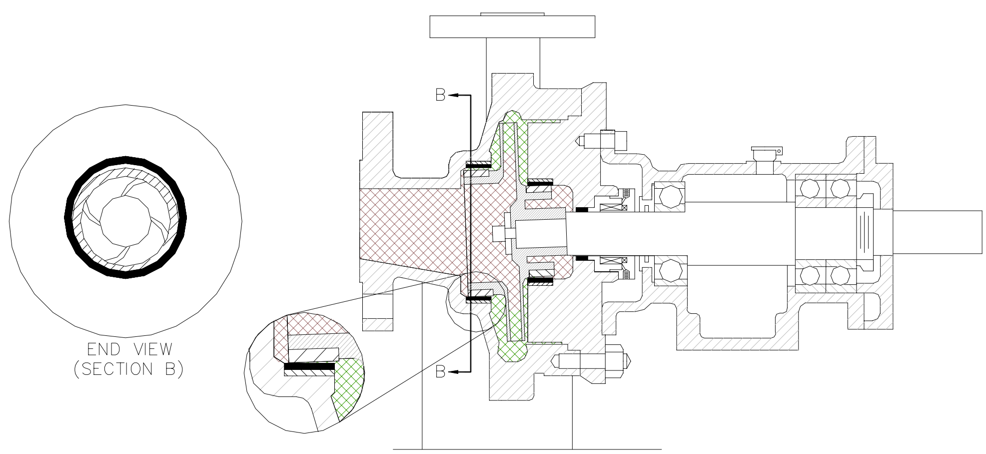
The function of wear rings

Wear rings are installed with close radial clearances and separate rotating and stationary, higher and lower-pressure sections of a pump. When shaft deflection occurs due to off-design operation, the wear rings contact. Historically, wear rings have been made from metal, which will gall and seize the pump under contacting or run-dry conditions, resulting in abrupt, high-energy pump failure. With metal wear rings, design clearance is increased to prevent failure, which has a negative effect on efficiency, suction conditions, and overall pump vibration. Vespel® CR-6100 can be installed with reduced clearances, without increasing the risk of seizure while improving pump performance.

Operational and safety benefits of Vespel® CR-6100 wear parts

Vespel® CR-6100 mitigates the risk of damage from wear ring contact, which can result from mechanical failure, off-design operation, or dry running. When metal wear rings contact, the extreme friction generates heat, the materials gall (friction weld), and the pump can seize. This is potentially a high energy, dangerous situation, which can result in extensive equipment damage and potential release of process fluid to the atmosphere. Vespel® CR-6100 wear rings minimize the risk of galling or seizure, thereby reducing the consequences of failure and risk of damage to expensive cast metal parts, reducing repair costs.

Vespel® CR-6100 wear rings also minimize the impact of run-dry conditions. Pumps resist seizure during periods of suction loss, off design operation, slow rolling, or start-up conditions. When the upset condition has been corrected, the pump can frequently continue in service without further damage or loss of performance. Conversely, pumps with metal wear rings exposed to these conditions frequently experience galling and seizure, requiring removal from service, disassembly, and repair.



The impact of off-design operation

Hydraulically off-design operation or mechanical faults result in shaft deflection and wear rings running off-center, frequently resulting in wear ring contact. When this occurs, metal wear rings can seize causing the pump to fail. Vespel® CR-6100 is not known to seize, allowing the pump to continue operation under these conditions.

Maintenance Benefits

For personnel who are repairing pumps, the easy installation of Vespel® CR-6100 reduces repair time. This increases equipment availability for service and reduces the operational tensions of long-term equipment repair. Repair time is reduced because parts can be produced and fitted quickly. Vespel® CR-6100 can be machined into parts with thin radial walls of 1/8” (up to 10” diameter) allowing application in nearly all pump configurations. The material properties of Vespel® CR-6100 allow it to be machined at high speeds and feed rates with the use of standard machine tooling. It does not require heat-treating or hard facing like some metal wear materials. In addition, material selection is simplified as Vespel® CR-6100 has near universal chemical compatibility and can run against metallic wear ring materials.

Superior properties of Vespel® CR-6100 for centrifugal pump wear parts

Vespel® CR-6100 has an excellent combination of properties, allowing material standardization over a wide range of process services due to its low coefficient of thermal expansion, high temperature limit, near universal chemical compatibility, excellent machining characteristics, high impact strength, low coefficient of friction, and high PV. The low coefficient of thermal expansion, low coefficient of friction, low wear rate, and high PV provide excellent run-dry performance. Vespel® CR-6100 machines easily and the high impact strength prevents breakage during installation and under pump operating conditions such as extreme cavitation, bearing failure, or high vibration.

The benefit of reduced clearances

When pumps don’t seize, wear ring clearance can be reduced. Reduced wear ring clearance increases reliability and performance. Table A lists sample Vespel® CR-6100 clearances compared to standard API clearances.

The reduction in clearance reduces internal pump re-circulation, which yields equivalent production flow while using fewer horsepower (i.e. increased efficiency). Applied on large pumps or across a large population of equipment, energy usage can be significantly reduced, delivering substantial annual savings. Alternatively, reduced clearance can increase the production capacity of existing equipment:

> A refinery alkylation unit was limited in production by a pair of product pumps. The first pump had recently been rebuilt, but more production was needed. The second pump was rebuilt with Vespel® CR-6100 with reduced clearance. When the second pump went on-line, production flow was increased by 7% compared to the first pump, allowing production targets to be achieved.

Reduced clearance also decreases the Net Positive Suction Head Required (NPSHR) of a typical pump by 2-3 feet, often providing the margin required in tough applications.

Table A: Sample of Vespel® CR-6100 compared to minimum API diametrical clearances

Bore Diameter (in.)	Vespel® CR-6100 Clearance (in.)	API Minimum Clearance (in.)
4.001—5.000	0.007	0.015
5.001—6.000	0.008	0.017
6.001—7.000	0.009	0.018
7.001—8.000	0.010	0.019
8.001—9.000	0.011	0.020

Application Guide

Vespel® CR-6100 is an outstanding material for pump wear rings, throat bushings, and line shaft bearings.

Service Limits

Vespel® CR-6100 can be used in temperatures up to 500 F. The low xy-plane thermal growth of Vespel® CR-6100 allows close clearances to be maintained over the entire temperature range. (Figure 1 shows the orientation of the xy-plane and z-direction.) Note that interference fits and axial clearance need to be adjusted with temperature.

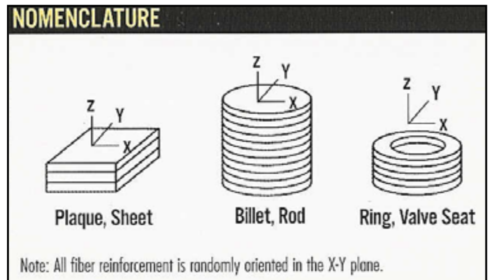


Figure 1: Orientation of material

Best performance is achieved in non-abrasive services. Vespel® CR-6100 has been installed with success in services with low concentrations of solids, however, performance may not be consistent due to many variables, which can cause premature wear. Pipe scale and other common debris in low concentrations are not typically a problem. Users should rely upon field experience and to apply appropriately.

Table B: Pump parts, which can be converted to Vespel® CR-6100.

Pump Type	Vespel® CR-6100 Parts
Overhung and Vertical Inline (API Pumps)	Stationary* wear rings and throat bushings.
Single stage between bearings	Stationary wear rings and throat bushings
Multi-stage horizontal	Stationary wear rings, throat bushings, inter-stage bushings, and pressure reducing bushings
Vertical	Stationary wear rings, inter-stage bushings, line shaft bearings, and throat bushings

* Vespel® CR-6100 should be mounted in compression, which in nearly all pumps will be the stationary, case and head rings.

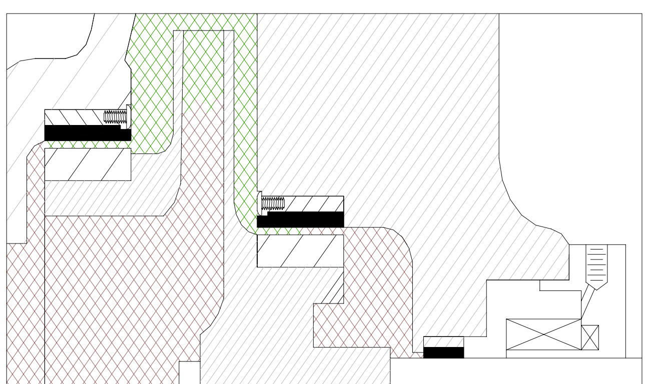


Figure 2: Installation of Vespel® CR-6100 wear rings and throat bushing in typical overhung pump.

Wear Rings

Vespel® CR-6100 is used as the stationary wear rings in a wide range of centrifugal pump types (Figure 2). For pumps in non-abrasive services under 500 F, Vespel® CR-6100 can be applied to reduce wear ring clearance, resulting in improved reliability and performance. Vespel® CR-6100 can also be applied to services prone to off-design operation, minimizing the risk of seizing failures associated with metal wear rings and allowing the pump to continue in service after temporary run-dry conditions.

Throat Bushings

Mechanical seals generally require a flush with a close clearance throat bushing installed to control the fluid environment at the mechanical seal. The close clearance forms a barrier, which isolates the mechanical seal environment from the process fluid. Vespel® CR-6100 throat bushings can used instead of specially fabricated, spring loaded, carbon bushings for close clearance applications. Vespel® CR-6100 bushings are less expensive, easier to install, and more durable than the specialty bushings. Vespel® CR-6100, installed with minimal clearance, improves the performance of several common seal flush plans used across the fluid processing industries

Vertical Pump Parts

Vespel® CR-6100 can be used for vertical pump line shaft bearings, wear rings, throat bushings (Figure 3). Typically these parts are made from rubber, bronze, carbon, or other materials, which can be replaced with Vespel® CR-6100. In light hydrocarbons, condensate, or other services with limited lubricity, Vespel® CR-6100 delivers a huge improvement in pump reliability.

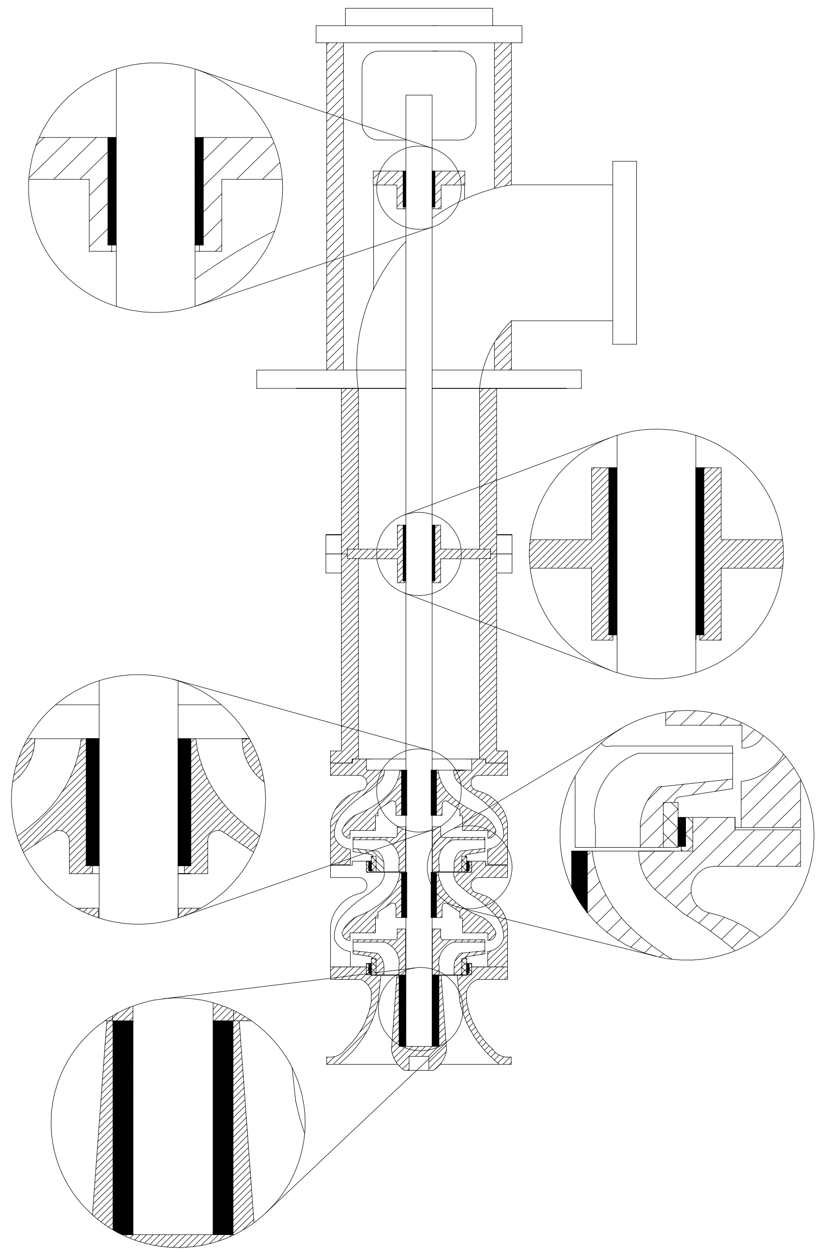


Figure 3: Vespel® CR-6100 parts installed in vertical pump.

Installation Guide

Vespel® CR-6100 pump components are easy to machine and install. Components are fitted into machined holders or directly into the pump casing, whichever is easier and more economical. Because Vespel® CR-6100 can be installed with thin radial walls (Appendix A, Table 5) end users often find that installing a Vespel® CR-6100 "sleeve" inside an existing metal wear component is the easiest way to use the material. Whether the Vespel® CR-6100 is installed as a sleeve or a solid component, it is essential for it to be installed with the correct interference fit, clearance, and end clearance for axial growth.

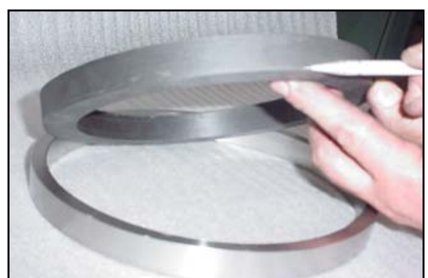
Step 1: Select interference fit from Table 1 or Table 2

Because metals have higher coefficients of thermal expansion than Vespel® CR-6100 in the xy-plane (the O.D./I. D. of a wear ring), the interference fit at ambient temperature will be different than interference fit at process temperature. Use maximum process fluid temperature and component diameter to determine fits.

A. Appendix A, Table 1 (Carbon Steel): shows the installation fits for a range of application temperature when Vespel® CR-6100 is installed into pumps made of carbon steel (or other metals with a similar coefficient of thermal expansion).

B. Appendix A, Table 2 (Stainless Steel): shows installation fits for a range of application temperatures when Vespel® CR-6100 is installed into metal components made of 300 series stainless steel (or other metals with similar coefficients of thermal expansion).

Step 2: Select running clearance from Table 3



Pilot or chamfer as indicated

Appendix A, Table 3 shows recommended running clearance based on component diameter. Unlike materials with high coefficients of thermal expansion, the installed clearance of Vespel® CR-6100 remains constant over the full application temperature range. This is because as temperature increases, stress in the material is relieved and the I.D. will increase at the same CTE as the material of the bore that it is pressed into. Temperature correction is only required when the impeller and case are different materials (which is true for all wear ring materials). Simply identify the I.D. of the Vespel® CR-6100 component, and select the appropriate clearance from the table.

Note: Where possible it is recommended to final machine the I.D. of the Vespel® CR-6100 component before the press fit operation. This practice maintains the maximum stress and interference fit in the component. In general, components with cross sections of less than 0.250" the bore will decrease on a 1 to 1 ratio with the interference fit (i.e. if the interference fit is 0.015", the bore will decrease by 0.015" after the press operation). This practice is possible due *to the dimensional stability of Vespel® CR-6100. It also saves time and money by eliminating the final machining step required with other materials Use the recommended interference fit and running clearance together to determine this free state machined I.D. size.*

Step 3: Establish end clearance

Vespel® CR-6100 has directional carbon fibers, which provide a low CTE in the X-Y plane. In the Z direction, the CTE is high (similar to the resin), which requires components to be installed with adequate end clearance. Appendix A, Table 4 shows required end clearance per inch of axial length for a given component in applications to 500 degrees.

Step 4: Press into bore

Using a hydraulic or arbor press, install the Vespel® CR-6100 component. Before pressing, be sure that the metal bore and Vespel® CR-6100 wear ring has been machined with an adequate lead-in chamfer and all sharp corners have been removed.

Note 1: Vespel® CR-6100 can be installed with soft (dead-blow type) hammer as an alternate or field installation practice.

Note 2: Short Vespel® CR-6100 bushings should not be pressed directly into the bottom of a long straight cylindrical bore, such as a seal chamber. Relief or metal holders are recommended for these applications.

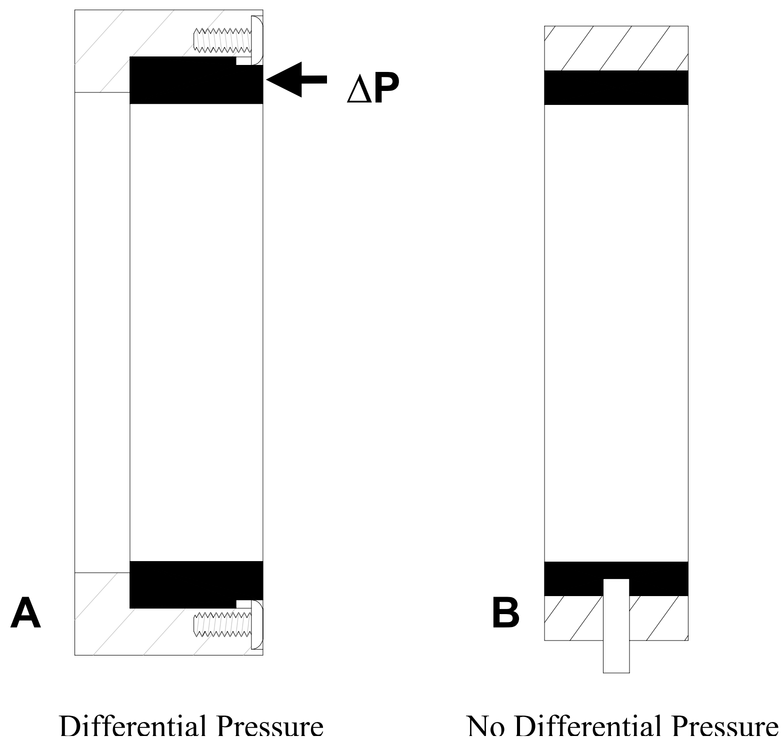
Step 5: Locking

Installed with the proper interference fit, field experience indicates additional mechanical locking devices in Vespel® CR-6100 Wear Rings are **not** required. However, API 610 recommends that wear rings be retained with locking pins, threaded dowels, or flanged and screwed methods.

To meet API 610 requirements for mechanical retention pins, screws or flanges can be installed into the metal material that is holding the Vespel® CR-6100. In shouldered applications (such as overhung pumps), machine screws, pins, or dog-point set screws can be utilized. When using machine screws scallops of different depth, milled prior to final press fitting will allow z-direction growth in one direction, at the screw heads (Figure 7, A). Pins shorter than the drilled depth can also be used. Other methods can also be used, providing they allow for z-direction growth. See Appendix A, Table 4 for minimum z-direction clearance requirement.

Differential pressure should be pushing the Vespel® CR-6100 against a shoulder (Figure 7, A). For applications with no differential pressure, radial pins can be used for retention (Figure 7, B).

Figure 7: Locking



Typically a shoulder 0.12 inch minimum thick is provided to prevent the stationary wear ring from becoming dislodged axially from the holder due to differential pressure. The radial wall thickness of the holder typically is 0.125 inch minimum. For applications where differential pressures are very high (> 250 psig per stage), or the pump has other unique characteristics, the solution should be engineered to fit.

Appendix A: Vespel® CR-6100 Pump Components
Recommended Installation Interference Fits

Table 1: Carbon Steel Case/Head

CTE= 6.5 x 10-6 in/in/F

	Pump Operating Temperature (deg F)									
Bore Diameter (in)	Ambient	100	150	200	250	300	350	400	450	500
	Recommended Interference Fit at Installation (in)									
0.001--1.000"	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005
1.001--2.000	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.007	0.008	0.008
2.001--3.000	0.007	0.007	0.008	0.009	0.009	0.010	0.010	0.011	0.011	0.012
3.001--4.000	0.008	0.008	0.009	0.010	0.011	0.012	0.013	0.013	0.014	0.015
4.001--5.000	0.010	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.018	0.019
5.001--6.000	0.012	0.013	0.014	0.015	0.017	0.018	0.019	0.021	0.022	0.023
6.001--7.000	0.014	0.015	0.016	0.018	0.019	0.021	0.023	0.024	0.026	0.027
7.001--8.000	0.016	0.017	0.019	0.021	0.022	0.024	0.026	0.028	0.029	0.031
8.001--9.000	0.018	0.019	0.021	0.023	0.025	0.027	0.029	0.031	0.033	0.035
9.001--10.000	0.020	0.021	0.024	0.026	0.028	0.030	0.033	0.035	0.037	0.039
10.001-11.000	0.022	0.023	0.026	0.028	0.031	0.033	0.036	0.038	0.041	0.043
11.001-12.000	0.024	0.026	0.028	0.031	0.034	0.036	0.039	0.042	0.045	0.047

Table 2: 300 Series Stainless Case/Head

CTE = 9.6 x 10-6 in/in/ F

	Pump Operating Temperature (deg F)									
Bore Diameter (in)	Ambient	100	150	200	250	300	350	400	450	500
	Recommended Interference Fit at Installation (in)									
0.001--1.000"	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.006
1.001--2.000	0.005	0.005	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.010
2.001--3.000	0.007	0.008	0.009	0.010	0.011	0.011	0.012	0.013	0.014	0.015
3.001--4.000	0.008	0.009	0.010	0.012	0.013	0.014	0.016	0.017	0.018	0.020
4.001--5.000	0.010	0.011	0.013	0.015	0.016	0.018	0.020	0.022	0.023	0.025
5.001--6.000	0.012	0.013	0.015	0.018	0.020	0.022	0.024	0.026	0.028	0.030
6.001--7.000	0.014	0.016	0.018	0.021	0.023	0.026	0.028	0.031	0.033	0.036
7.001--8.000	0.016	0.018	0.021	0.024	0.027	0.029	0.032	0.035	0.038	0.041
8.001--9.000	0.018	0.020	0.023	0.027	0.030	0.033	0.037	0.040	0.043	0.047
9.001--10.000	0.020	0.022	0.026	0.030	0.033	0.037	0.041	0.044	0.048	0.052
10.001-11.000	0.022	0.024	0.029	0.033	0.037	0.041	0.045	0.049	0.053	0.057
11.001-12.000	0.024	0.027	0.031	0.036	0.04	0.045	0.049	0.054	0.058	0.063

Table 3: Recommended Running Clearance

Bore Diameter (in.)	Diametrical Clearance (in.)
0.000—1.000	0.004
1.001—2.000	0.004
2.001—3.000	0.005
3.001—4.000	0.006
4.001—5.000	0.007
5.001—6.000	0.008
6.001—7.000	0.009
7.001—8.000	0.010
8.001—9.000	0.011
9.001—10.000	0.012
10.001—11.000	0.013
11.001—12.000	0.014

Table 4: Axial End Clearance

Process Temperature (F)	Axial Growth at Temperature per Inch (based on 68 F process temperature)
-50	-0.020
0	-0.012
50	-0.003
100	0.006
150	0.015
200	0.024
250	0.033
300	0.042
350	0.054
400	0.067
450	0.092
500	0.118

Table 5: Minimum Wall Thickness

Bore Diameter (in.)	Minimum Wall Thickness (in.)
0.000—2.000	0.062
2.001—4.000	0.087
4.001—10.000	0.125
10.001—12.000	0.125

Note: Wall thickness as low as 0.062" can be achieved for all sizes if the bore is machined to size after interference fit into the pump case or assembled into a metal backing ring.

For more information about DuPont™ Vespel®:

UNITED STATES
DuPont Engineering Polymers
Pencader Site
Newark, DE 19714-6100
Tel: 800-222-VESP
Fax: (302) 733-8137

EUROPE
DuPont de Nemours
(Belgium) BVBA-SPRL
Engineered Parts Center
A. Spinoystraat 6
B-2800 Mechelen
Belgium
Tel: ++32 15 441527
Fax: ++32 15 441408

ASIA-PACIFIC

Japan
DuPont K.K.
Arco Tower
8-1, Shimomeguro 1-chome
Meguro-ku, Tokyo 153-0064
Tel: 03-5434-6989
Fax: 03-5434-6982

Korea
DuPont Korea Limited
4/5 Floor, Asia Tower, #726
Yeoksam-dong, Kangnam-ku
Seoul 135-082
Tel: 02-222-5200
Fax: 02-222-5470

Taiwan/ China
DuPont Taiwan Limited
13th Floor, Hung Kuo Building
167, Tun Hwa North Road
Taipei, Taiwan 105
Tel: 02-719-1999
Fax: 02-712-0460

CAUTION: Do not use DuPont materials in medical applications involving permanent implantation in the human body or permanent contact with internal body fluids or tissues.

Do not use DuPont materials in medical applications involving brief or temporary implantation in the human body or contact with internal body fluids or tissues, unless the material has been provided directly from DuPont under a contract which expressly acknowledges the contemplated use.

DuPont makes no representation, promise, express warranty or implied warranty concerning the suitability of these materials for use in implantation in the human body or in contact with internal body fluids or tissues.

VCR6100PUMP-12/01/02